

ISS Exploration and Non-Exploration Research Project

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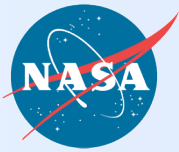
GRC Projects

EXPLORATION

- ◆ Program Management
- ◆ Combustion Integrated Rack (CIR)
- ◆ Fluids Integrated Rack (FIR)
- ◆ FCF Sustaining Engineering
- ◆ ISS Operations: Integration & Operations (I&O) and Telescience Support Center (TSC)
- ◆ Mission Integration & Planning (MIP)
- ◆ Multi-User Droplet Combustion Apparatus (MDCA)/ Flame Extinguishment Experiment (FLEX)
- ◆ Light Microscopy Module (LMM)/ Constrained Vapor Bubble (CVB)
- ◆ Boiling Experiment Facility (BXF)
- ◆ Smoke Aerosol Measurement Experiment (SAME)/ Dust and Aerosol measurement Feasibility Test (DAFT)
- ◆ Capillary Flow Experiments (CFE)

NON-EXPLORATION

- ◆ Space Acceleration Measurement Systems (SAMS)/ Microgravity Acceleration Measurement System (MAMS)
- ◆ Binary Colloidal Alloy Test (BCAT-3+ / BCAT-4)
- ◆ Coarsening in Solid-Liquid Mixtures-2 (CSLM-2)
- ◆ Investigating the Structures of Paramagnetic Aggregates (InSPACE-2)
- ◆ Multi-User Droplet Combustion Apparatus (MDCA)/ Flame Extinguishment Experiment (FLEX-2)
- ◆ Capillary Channel Flow (CCF)
- ◆ Shear History Extensional Rheology Experiment (SHERE)
- ◆ Smoke Point in Coflow Experiment (SPICE)
- ◆ Zero Boil-Off Tank Experiment (ZBOT)
- ◆ Gradient Driven Fluctuations Experiment (GRADFLEX)
- ◆ Boiling and Two Phase Laboratory Grant (2 ϕ Flow)



Program Management (PM)

WBS: 825080.01.02.20.01

ISS & Non-Exploration Research Project Manager: Dr. Fred J. Kohl, NASA GRC

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ISS Flight Projects Manager: Thomas St. Onge, NASA GRC

Objective:

- ◆ Manage GRC flight and ground-based projects for NASA's Exploration and Non-Exploration Research Programs.
- ◆ Coordinate and integrate the Advanced Capabilities Division's flight and ground-based projects for NASA's Exploration and Non-Exploration Research Programs.
- ◆ Coordinate and integrate GRC flight projects with the ISS Payloads Office.

Relevance/Impact:

- ◆ Management, including all supporting functions, of the ISS Exploration and Non-Exploration Research Project is necessary to ensure the successful implementation of the technical tasks within the project.

Approach:

- ◆ Participate in weekly HQs, Level 2 and Center telecons to resolve programmatic issues and move the program forward.
- ◆ Participate in the weekly ISS PCB, RPWG, PMIT and PIM telecons to resolve technical, integration and manifest issues.
- ◆ Deliver safe and reliable flight payloads for operation on ISS and provide PIs with the necessary data to support and further develop their research.
- ◆ Operate and maintain the unique and efficient ground-based facilities (C-9, 2.2-Second and Zero Gravity Drop Towers, labs, etc.).
- ◆ Educate the public and advocate for exploration and non-exploration research on the ISS and in ground-based facilities to address the difficult technical issues associated with long duration spaceflight.
- ◆ Collaborate with International Partners for cost effective means to conduct research on ISS.
- ◆ Coordinate budget formulation, implementation and reporting.



Combustion Integrated Rack (CIR)

WBS: 825080.04.02.20.01



PM: Terence O'Malley, NASA GRC
Engineering Team: ZIN Technologies, Inc.

Objective:

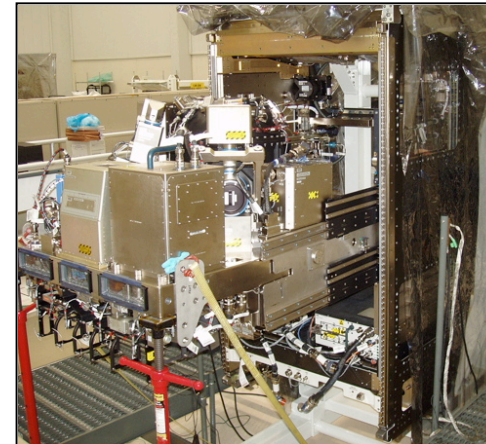
- The Combustion Integrated Rack is a facility designed to support sustained systematic combustion research and technology experiments on the International Space Station.

Relevance/Impact:

- The CIR will accommodate experiments that address critical needs in the areas of spacecraft fire safety (i.e., fire prevention, detection and suppression), incineration of solid wastes, power generation, flame spread, soot and polycyclic aromatic hydrocarbons, in-situ resource utilization, environmental monitoring and materials synthesis.

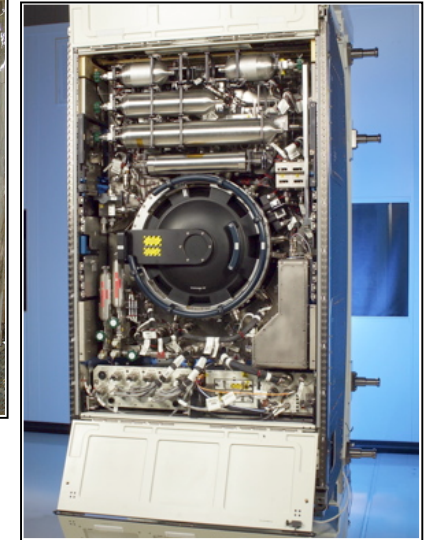
Development Approach:

- The CIR is being developed as part of the Fluids & Combustion Facility (FCF).
- The FCF system consists of a Flight Segment and a Ground Segment.
- All avionics and diagnostics are contained in orbital replacement units with simple interfaces that allow for easy change-out/reconfiguration.
- Protoflight approach was taken for most of the hardware.
- FCF operates together with payload experiment equipment, ground-based operations facilities and the FCF ground segment.
- The CIR is designed for remote/autonomous operations.



(Above) CIR rack with bench rotated (Right) CIR Flight Rack

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ISS Resource Requirements

Accommodation (carrier)	ISS US Laboratory
Upmass (kg) (w/o packing factor)	881
Volume (m³) (w/o packing factor)	0.4 (stowed hardware)
Power (kw) (peak)	1.9 Kw
Crew Time (hrs) (initial installation & setup)	25
Launch/Increment	ULF-2/Increment 17 ⇒

Project Life Cycle Schedule

Milestones	SCR	HCR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	N/A	6/1998	2/2001	5/2002	2/2003	7/2005	12/2006	8/2008	Inc. 17 ⇒	TBD	TBD



Fluids Integrated Rack (FIR)

WBS: 825080.04.02.20.01



PM: Ron Sicker, NASA GRC

Engineering Team: ZIN Technologies, Inc.

Objective:

- ◆ Develop a flexible, easily configurable, multi-use facility that provides core diagnostics and data acquisition & control capabilities that will support a broad range of research in support of Space Exploration and other endeavors.

Relevance/Impact:

- ◆ The Fluids Integrated Rack (FIR) will support strategic research to enable storage/transfer of two-phase fluids, characterize two-phase heat transfer, support development of multi-phase environmental controls for life support systems, and support human health in physiological/medical systems research to enable long term missions to the Moon and Mars.

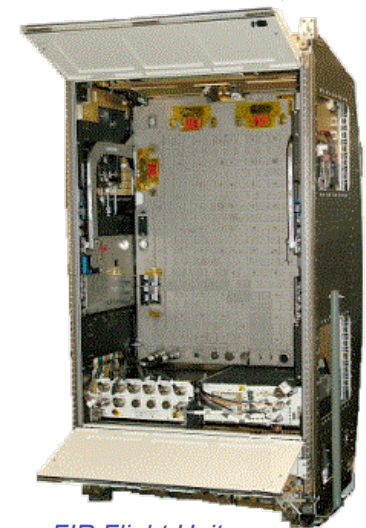
Development Approach:

- ◆ The FIR is being developed as part of the Fluids & Combustion Facility (FCF).
- ◆ The FCF system consists of a Flight Segment and a Ground Segment.
- ◆ All avionics and diagnostics are contained in orbital replacement units with simple interfaces that allow for easy change-out/reconfiguration.
- ◆ Protoflight approach was taken for most of the hardware.
- ◆ FCF operates together with payload experiment equipment, ground-based operations facilities and the FCF ground segment.
- ◆ The FIR is designed for remote/autonomous operations.

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FIR with the Light Microscopy Module



FIR Flight Unit

ISS Resource Requirements

Accommodation (carrier)	ISS US Laboratory
Upmass (kg) (w/o packing factor)	745 (includes upmass for stowed ARIS hardware)
Volume (m³) (w/o packing factor)	0.12 (off-rack ascent volume)
Power (kw) (peak)	1.1
Crew Time (hrs) (initial installation & setup)	6
Launch/Increment	17A/Increment 19 ⇒

Project Life Cycle Schedule

Milestones	SCR	HCR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	N/A	6/1998	2/2001	12/2002	2/2003	7/2005	12/2006	1/2009	Inc. 19 ⇒	TBD	TBD



FCF Sustaining Engineering (FCF)

825080.04.02.20.01



PM: Robert Corban, NASA GRC
Engineering Team: ZIN Technologies, Inc.

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Objective:

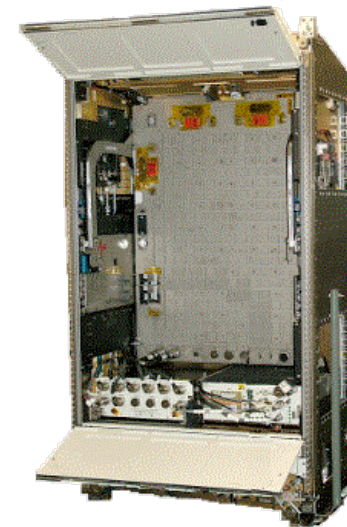
- ◆ Provide the engineering sustaining engineering support for the CIR & FIR, along with Telescience operations & FCF On-orbit operations,
- ◆ Complete all FCF products that includes any remaining GIU activities, integration and operations products, TSC readiness, and Mission Integration Planning.
- ◆ Prepare the FCF flight units for launch that includes post-storage review and flight readiness reviews.

Relevance/Impact:

- ◆ Support strategic research on the ISS in support of the Exploration Initiative, as well as basic research.
- ◆ Provide telescience operations for the payload community in support of ISS operations.

Development Approach:

- ◆ Maintain the Prime Contractor workforce to assure development knowledge is retained.
- ◆ Complete operational products using the existing team.
- ◆ Advocate for the FIR & CIR to be the payloads of choice for ULF-2.



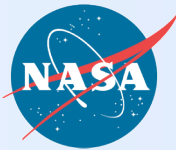
FIR Flight Unit



CIR Flight Unit

Schedule

Key Milestones/Deliverables	Date
FIR GIU Acceptance	11/2006
FIR & CIR FHA	12/2006
CIR GIU Acceptance	5/2007
Spares Completed	2/2008
TSC/FCF Readiness Review	3/2008
COFR	5/2008
Launch (CIR)	8/2008
MDCA On-Orbit Operations Begin	9/2008
Launch (FIR)	1/2009
LMM On-Orbit Operations Begin	2/2009



ISS Operations

Integration & Operations and Telescience Support Center (I&O and TSC)

WBS: 825080.04.02.20.03



PM: Kevin McPherson, NASA GRC

Engineering Team: ZIN Technologies, Inc.

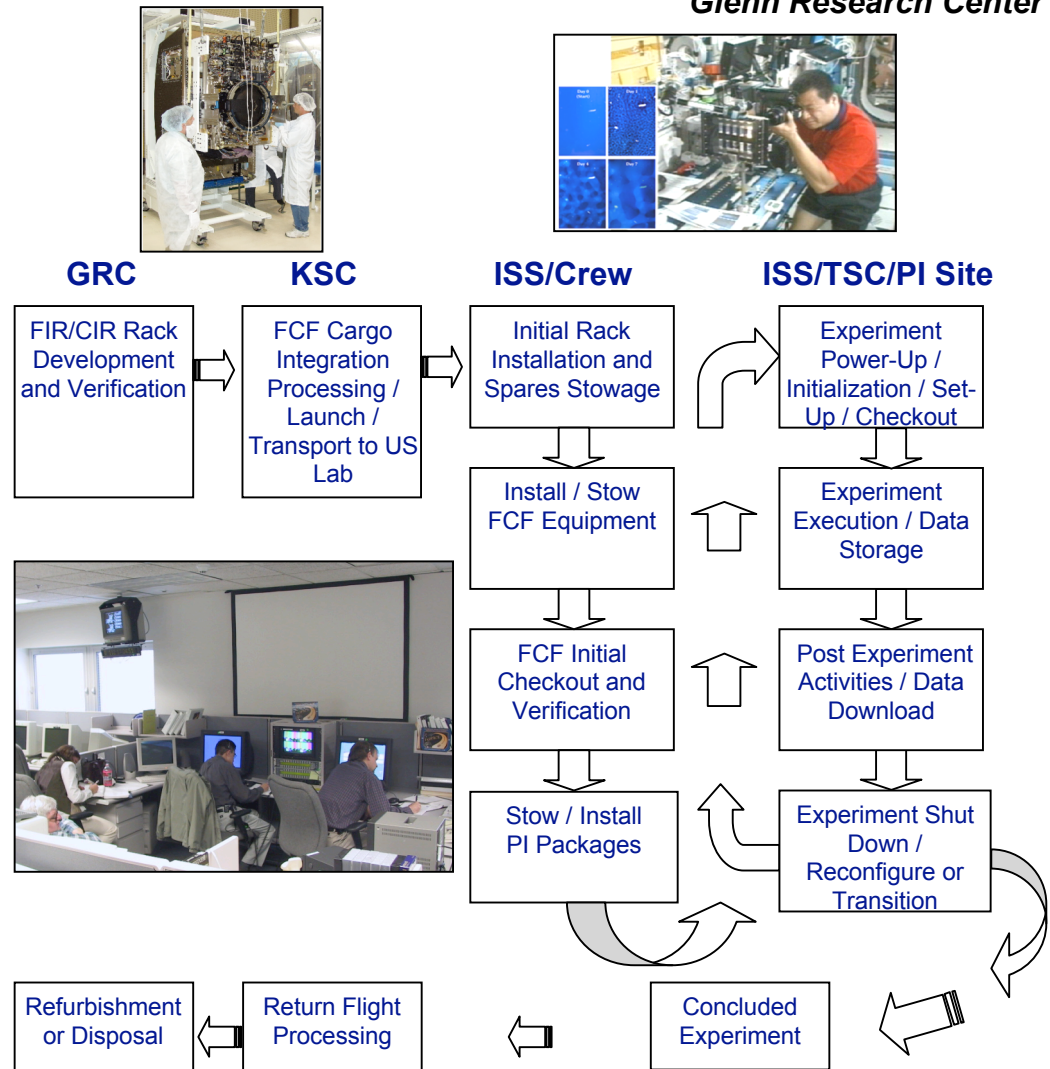
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Objective:

- ◆ The ISS Operations concept seeks to maximize use of FCF resources by minimizing crew interaction with the facility hardware. This is accomplished primarily by controlling the majority of activities via telescience.
- ◆ ISS Operations are conducted from the TSC at GRC.
- ◆ Crew involvement is nominally limited to initial setup and sample/resource changeout.

Integration & Operations Approach:

- ◆ The FCF hardware will be launched on-board the Space Shuttle, carried in the cargo bay of the Multi-Purpose Logistics Module (MPLM). Payloads will be delivered via Shuttle or other launch vehicle (e.g., ATV) to ISS for integration with FCF.
- ◆ The crew will configure various ORUs, support on-orbit sample replacement/exchange, and selected systems calibration for each experiment.
- ◆ The TSC will house the console operators and provide the capabilities for payload commanding; telemetry acquisition, distribution, processing, ISS video displays and voice communication.



Project Life Cycle Schedule

Milestones	URC	FHA	Crew Procedures	Crew Training	On-Line Testing (KSC)	ORR	CoFR	Launch	Ops	Return	Final Report
Actual/ Baseline	L -18	L -12	L-5.5	L -10/3	L -6	L -3	L -6wks	L -0	Inc 17	L+6	L +18



MIP Team: Robert Hawersaat, NASA GRC
James Stroh, ZIN Technologies

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Objective:

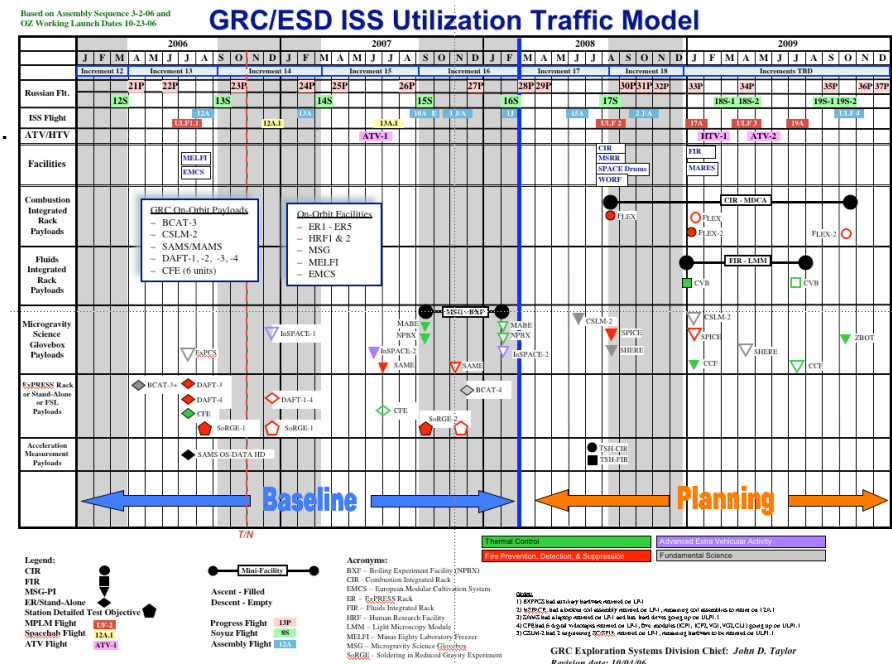
- ◆ Manage GRC/ESD payload integration and manifesting processes.
- ◆ Support the ESD Management and Project Managers in payload planning.
- ◆ Support FCF integration with the ISS Payload Office.

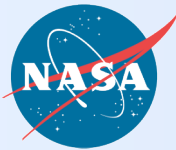
Relevance/Impact:

- ◆ Develop and maintain an accurate database for the GRC/EDS payloads including ExPRESS rack, MSG, and FCF payloads.
- ◆ Support GRC/ESD management and payload developers in payload Certification of Flight Readiness (CoFR) process.
- ◆ Develop and update the GRC/ESD ISS Traffic Model to reflect the current ISS assembly sequence and the actual GRC ISS payload traffic (up/down/on-orbit).

Approach:

- ◆ Participate in the weekly RPWG, PMIT Teleconferences.
- ◆ Work with GRC/ESD payload developers to submit the Change Evaluation Form (CEF), Operation Change Request (OCR) to ISS Payload Office (JSC/OZ) for changes to payload resource or operation requirements.
- ◆ Develop and maintain the payload data collection system for the GRC/ESD payloads.
- ◆ Perform ISS payload planning, traffic model analyses, ISS change (PIRN/CR) and exception processing.
- ◆ Update the GRC/ESD ISS Traffic Model routinely to reflect the latest ISS assembly sequences and GRC/ISS payload traffic.
- ◆ Prepare and submit to the HQ, JSC/OZ, and MSFC the required CoFR letters and endorsement products for the GRC/ESD payloads .
- ◆ Participate in the Increment/Flight CoFR Readiness Reviews.





Multi-User Droplet Combustion Apparatus (MDCA)/ Flame Extinguishment Experiment (FLEX)

WBS: 825080.04.02.20.04



PI Team: Prof. Forman Williams, UCSD (lead)
Prof. Frederick Dryer, Princeton
Prof. Mun Choi, Drexel University
Prof. Benjamin Shaw, USC-Davis

PS: Michael Hicks, NASA GRC

PM: Terence O'Malley, NASA GRC

Engineering Team: ZIN Technologies, Inc.

Objective:

- ♦ Modular apparatus designed for fire suppression/flame extinguishment investigations.
 - Assess the effectiveness of suppressants in microgravity.
 - Quantify the effect of candidate exploration atmospheres on fire suppression characteristics.
 - Provide data to develop of simplified combustion models.

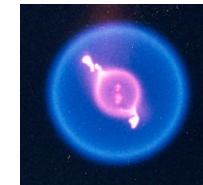
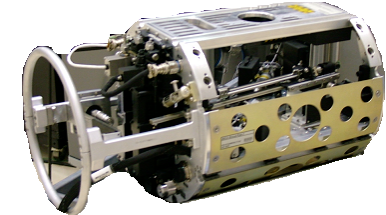
Relevance/Impact:

- ♦ Direct the definition and development of large-scale fire suppression tests.
- ♦ Provide the direction for the selection of fire suppressant for CEV and LSAM.
- ♦ Allow the development of rational design rules for fire suppression in exploration vehicles and habitats.

Development Approach:

- ♦ Flight design leverages off previous flight design heritage (STS-83/94).
- ♦ Multi-user, re-usable apparatus minimizing up-mass/volume, costs, and crew involvement.

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(Left) FLEX Chamber Insert Assembly installed in the Combustion Integrated Rack. (Top Right) FLEX Chamber Insert Assembly Apparatus. (Bottom Right) Color image of a burning droplet.

ISS Resource Requirements

Accommodation (carrier)	Combustion Integrated Rack
Upmass (kg) (w/o packing factor)	254 kg
Volume (m ³) (w/o packing factor)	0.48 m ³
Power (kw) (peak)	0.73 Kw
Crew Time (hrs) - Initial configuration of CIR Rack - Change-outs during experiment	8.5 hrs 8.3 hrs
Launch/Increment	ULF-2/Increment 17/18/19

Project Life Cycle Schedule

Milestones	FY95 NRA Process	HCR/RDR	CDR	VRR	Safety (PH-3)	PSR-2	Ship	Launch	Ops	Return	Final Report
Actual/ Baseline	Nov 1998	Aug 2001	July 2003	March 2004	Sept 2005	June 2006	L-7	Aug 2008	Sept 2008	Mar 2009	Mar 2010

Revision Date: 10/30/2006



Light Microscopy Module (LMM)/ Constrained Vapor Bubble (CVB)

WBS: 825080.04.02.20.06



PI: Prof. Peter C. Wayner, Jr., Rensselaer Polytechnic Institute

PS: David F. Chao, NASA GRC

PM: Ronald Sicker, NASA GRC

Engineering Team: ZIN Technologies, Inc.

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Objective:

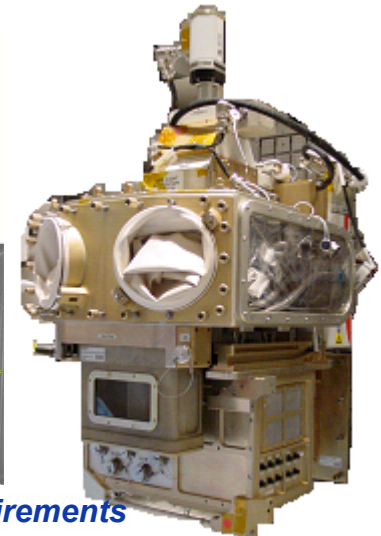
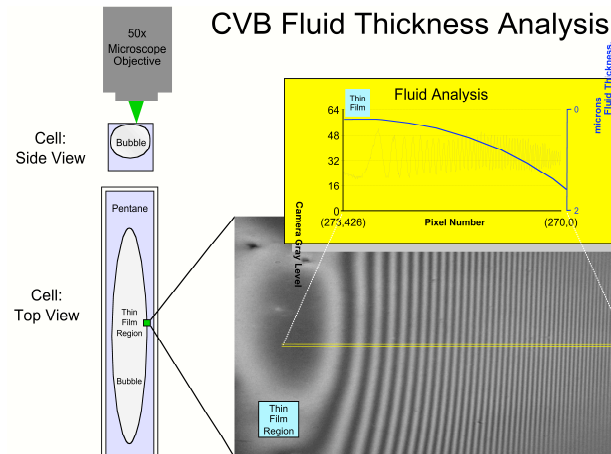
- To determine the overall stability, the fluid flow characteristics, the average heat transfer coefficient in the evaporator, and heat conductance of the constrained vapor bubble, under microgravity conditions, as a function of vapor volume and heat flow rate.

Relevance/Impact:

- CVB is crucial for engineering heat pipes for space applications.
- CVB flow induced by capillary flow eliminating need for wicks.
- Data from CVB will lead to optimally designed heat pipes that will operate at full capacity and provide large weight savings.
- CVB will provide the understanding of the maximum achievable performance of simple heat pipes based on corner flows.
- LMM provides the capability to identify contaminants in the crew environment without the need to return samples to earth for evaluation.
- LMM provides capability to quantify blood samples of crew members for flight surgeon analysis.
- LMM provides capabilities to identify microorganisms with a broad suite of optical diagnostics including fluorescence microscopy.

Development Approach:

- The CVB/LMM is designed for autonomous operation through scripts and ground commanding. Crew time is required for initial installation and check out in the Fluids Integrated Rack (FIR), sample change out, and removal from FIR.
- The LMM and CVB flight hardware was developed under a proto-flight approach with the exception of the CVB module which follows the traditional qual/flight approach. The CVB modules will have spares, all other spare hardware will be kitted and assembled as required.
- The LMM and CVB are designed to utilize the FIR capabilities to the maximum extent possible.



ISS Resource Requirements

Accommodation (carrier)	Fluids Integrated Rack (FIR)
Upmass (kg) (w/o packing factor)	203 Kg for CVB/LMM
Volume (m³) (w/o packing factor)	0.09 CVB/LMM
Power (kw) (peak)	0.5kw for CVB/LMM 1.1 kw for FIR/CVB/LMM
Crew Time (hrs) (installation/operations)	34 Hours
Autonomous Operation	2wks/module 5 modules = 10 wks
Launch/Increment	ULF-2/Increment 17/18/19

Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	9/97 CVB	12/98 CVB	2/02 LMM/CVB	12/03 LMM/CVB	8/04 LMM/CVB	Phase III 11/05	12/07	1/09	1/09-6/09 Inc. 17	9/09	9/10

Revision Date: 10/30/2006



Boiling Experiment Facility (BXF)

WBS: 825080.04.02.20.07



PIs: Prof. Jungho Kim, University of Maryland; Prof. Vijay Dhir, University of California-LA

PS: John McQuillen, NASA GRC; David Chao, NASA GRC

PM: Franklin Vergilii, NASA GRC

Engineering Team: ZIN Technologies, Inc.

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Objective:

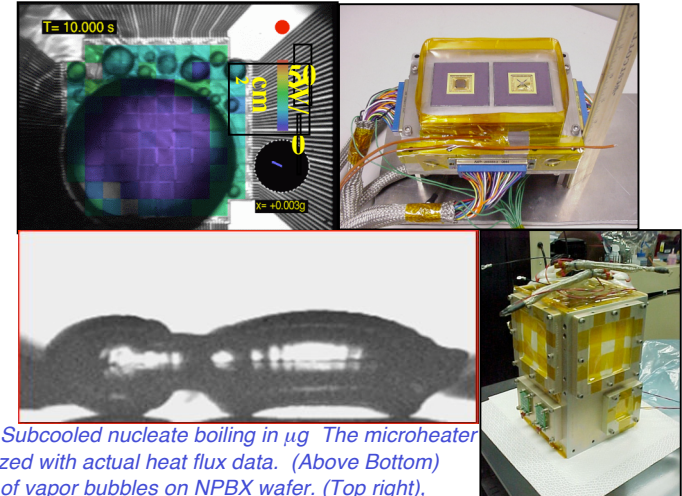
- ◆ Determine the local boiling heat transfer mechanisms in microgravity for nucleate and transition boiling and critical heat flux.
- ◆ To understand bubble growth, detachment and subsequent motion of single and large merged bubbles.

Relevance/Impact:

- ◆ Boiling thermal management systems provide isothermal control, reducing the temperature difference between the heat source and radiator. Higher radiator temperatures reduce the area and weight of the radiator.
- ◆ Pool Boiling is an effective means of studying Flow Boiling.
 - Models to predict flow boiling heat transfer coefficients consist of pool boiling and liquid phase forced flow convection models.
 - The “No Flow” case is pool boiling in a confined area.

Development Approach:

- ◆ Two experiments, Microheater Array Boiling Experiment (MABE) and Nucleate Pool Boiling Experiment (NPBX) utilize the common BXF flight hardware/software system.
- ◆ For cost reduction, BXF was developed as Protoflight hardware, there was no engineering model. Minimum critical spares are available/purchased. Risk mitigation is by functional, environmental, and burn-in testing, plus additional verification methods.
- ◆ Carrier is ISS Microgravity Science Glovebox (MSG). Will provide gravitational data to Principal Investigators using Space Acceleration Measurement Systems (SAMS) triaxial sensor head (TSH).
- ◆ Autonomous operation, Increment 16, with minimal ISS Crew time required for set up, video tape and hard drive exchanges, and equipment stowage.



(Above Top:) Subcooled nucleate boiling in μg . The microheater array is colorized with actual heat flux data. (Above Bottom) Coalescence of vapor bubbles on NPBX wafer. (Top right), MABE heater assembly being prepared for calibration. (Bottom right) test chamber.

ISS Resource Requirements

Accommodation (carrier)	Microgravity Science Glovebox
Upmass (kg) (w/o packing factor)	98.2
Volume (m ³) (w/o packing factor)	0.144
Power (kw) (peak)	0.785 (includes MSG Power)
Crew Time (hrs) (installation/operations)	8
Autonomous Ops Time (hrs)	832: MABE 784; NPBX 48
Launch/Increment	10A/Increment 15

Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	9/2001	12/2002	5/2003	12/2003	3-7/06	PH.III-6/06	5/07	NET 8/09/07	Incr. 16	Ops +4 m	Return + 12m

Revision Date: 10/30/2006



Smoke Aerosol Measurement Experiment (SAME)

WBS: 825080.04.02.20.05



PI: David Urban, NASA GRC

PS: Gary Ruff, NASA GRC

PM: William Sheredy, NASA GRC

Engineering Team: ZIN Technologies, Inc.

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Objective:

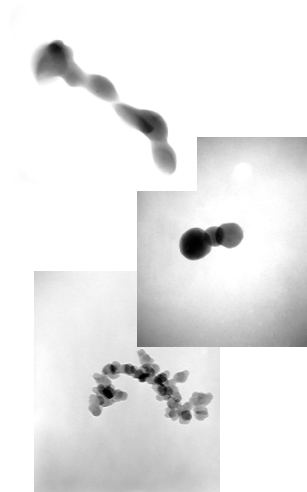
- Quantify particulate fire signatures in microgravity by measuring moments of smoke particulate size distribution from typical spacecraft materials in microgravity.
- Evaluate the performance of the two existing U.S. spacecraft smoke detector designs in microgravity.
- Evaluate advanced fire detection sensors (e.g. species-specific sensors and E-Nose).

Relevance/Impact:

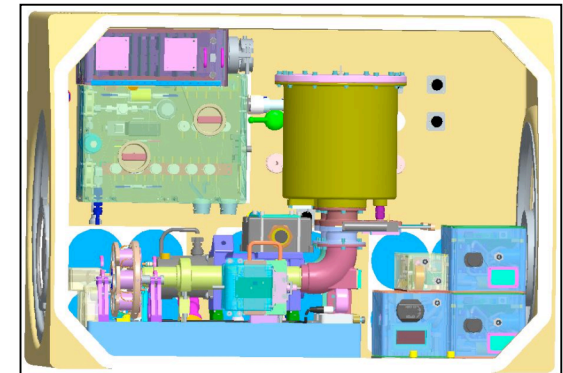
- SAME will provide data required for the rational development of fire particulate detectors on exploration vehicles and habitats.

Development Approach:

- SAME will rely on the DAFT experiment to prove the μg performance of the P-Trak, a key diagnostic.
- The project team is pursuing a protoflight development approach.
- After initial setup by the crew, the experiment will utilize uplinked parameters for autonomous operations. Consumables will be periodically changed out by the crew.



Images of microgravity particulate from overheated Teflon & Kapton & candle soot.



SAME in the MSG

ISS Resource Requirements

Accommodation (carrier)	Microgravity Science Glovebox
Upmass (kg) (w/o packing factor)	52
Volume (m³) (w/o packing factor)	0.15
Power (kw) (peak)	0.230
Crew Time (hrs) (installation/operations)	14
Autonomous Ops Time (hrs)	60
Launch/Increment	13A.1/Increment 15

Project Life Cycle Schedule

Milestones	RDR	IERRR	PDR/CDR	Safety	VRR	PSR	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	4/04	1/05	2/06	4/06	8/06	12/06	12/06	6/07	8/07	TBD	Late 08

Revision Date: 10/30/2006



Dust and Aerosol measurement Feasibility Test (DAFT)

WBS: 825080.04.02.20.05



PI: David Urban, NASA GRC

PS: Gary Ruff, NASA GRC

PM: William Sheredy, NASA GRC

Engineering Team: ZIN Technologies, Inc.

Objective:

- DAFT is a risk mitigation experiment to evaluate the performance of the TSI P-Trak, a commercially available Condensation Nuclei Counter (CNC), in a microgravity environment.

Relevance/Impact:

- DAFT serves as a technology demonstration that mitigates significant technical risk to the success of the Smoke Aerosol Measurement Experiment (SAME). P-Trak is a key diagnostic identified for use with SAME.
- An added benefit is that DAFT will provide air quality measurements in the ISS cabin.

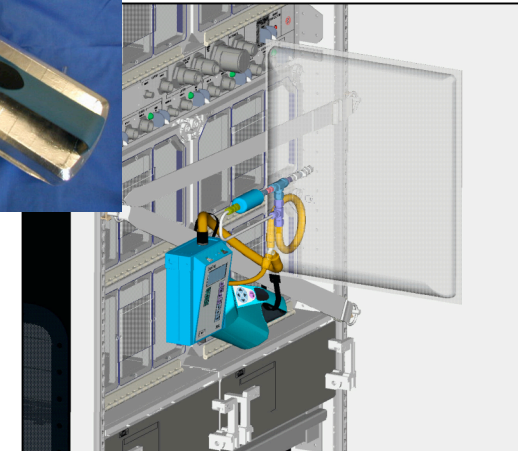
Development Approach:

- Due to upmass constraints, DAFT was divided into four separate, functional packages (DAFT-1 through DAFT-4).
- DAFT-1 and DAFT-2 were delivered to the ISS aboard flight 16P in December, 04 and operated during February and March, 05. P-Trak appeared to operate nominally.
- The accuracy of the measurements can only be assessed using a measurement standard (DustTrak) and known aerosol (Arizona Road Dust) to be flown with DAFT-3 and DAFT-4.



P-Trak, Alcohol Wick (w/Container) and Batteries.

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DAFT-3 Configuration, Sample Bag Deflation.

ISS Resource Requirements

Accommodation (carrier)	EXPRESS Rack
Upmass (kg) (w/o packing factor)	7.2 (DAFT-3 and -4)
Volume (m³) (w/o packing factor)	0.044 (DAFT-3 and -4)
Power (kw) (peak)	0 (Power supplied by PD provided batteries)
Crew Time (hrs) (installation/operations)	15 (Not continuous, Negotiable)
Operating Time (hrs)	0 (No autonomous ops)
Launch/Increment	ULF1.1/Increment 13/14

Project Life Cycle Schedule

Milestones	PSR/FHA	Phase III Safety	DAFT-1 & -2 Launch	Ops	DAFT-3 & -4 Launch	Ops	Return	Final Report
Actual/ Baseline	8/03	10/03	12/04	2-3/05	7/06	Inc 13	12/06	12/06



Capillary Flow Experiments (CFE)

WBS: 825080.04.02.20.08



PI: Professor Dr. Mark Weislogel, Portland State University

PS: Robert Green, NASA GRC

PM: Donna Bohman, NASA GRC

Engineering Team: ZIN Technologies, Inc.

Objective:

- Investigate capillary flow in the management of fluid systems in space.
- Exploration missions assume the use of larger liquid propellant masses ever flown on interplanetary missions. Capillary forces can be exploited to control fluid orientation to enable large mission-critical system predictable performance.

Relevance/Impact:

- Technology in space uses capillary forces to position and transport fluid. CFE provides improved design knowledge in the storage and transport of liquids in space thereby increasing system reliability, decreasing system mass, and reducing overall system complexity.

Development Approach:

- CFE comprises three related experiments with two unique experimental units per experiment for a total of six units. Each test unit provides relevant capillary resulting phenomena, critical wetting in discontinuous structures, large length scale contact line damping, and capillary flow in complex containers.

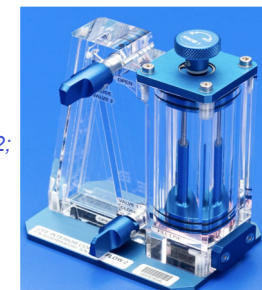
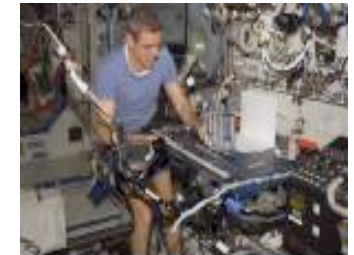
On-Orbit Status:

- CFE is time-lined as a reserve payload.
- Operated CL2, CL2, and VG1 during Increment 12/13.
- CFE flight tapes are being processed and will be delivered to the PI, Mark Weislogel.

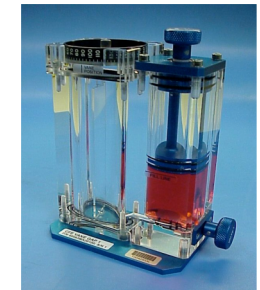
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(Left) Interior Corner Flow 1;
(Right) Increment 12 CL2
ops with Bill McArthur.



(Left) Interior Corner Flow 2;
(Right) Vane Gap1&2.



ISS Resource Requirements

Accommodation (carrier)	MWA
Upmass (kg) (w/o packing factor)	6.37
Volume (m³) (w/o packing factor)	0.012
Power (kw) (peak)	0
Crew Time (hrs) (installation/operations)	35
Launch/Increment	ULF1.1/Increment 14/15

Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline								ULF1.1 7/4/2006	Inc. 14/15	TBD	TBD

Revision Date: 10/30/2006



Space Acceleration Measurement Systems (SAMS)

WBS: 825080.04.02.30.01



PM: R. Hawersaat, GRC

Engineering Team: ZIN Technologies, Inc.

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Objective:

- ◆ Provide acceleration measurement systems that meet the requirements of the researchers on board the International Space Station.
- ◆ SAMS measures the acceleration environment in the 0.01 to 400 Hz range for payloads.

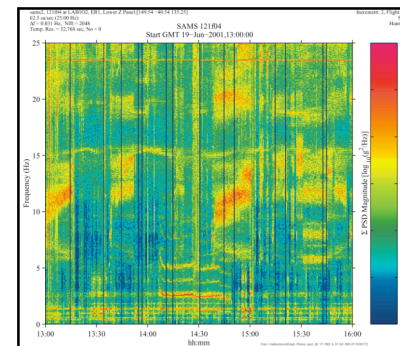
Relevance/Impact:

- ◆ SAMS will measure the acceleration environment for research payloads and other customers on board the ISS.

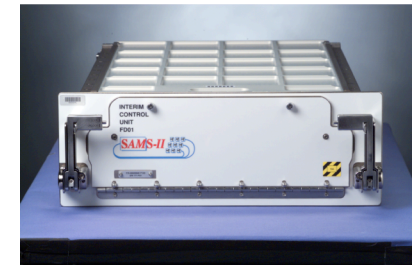
Development Approach:

- ◆ SAMS was developed using a dedicated function approach using an Interim Control Unit and SAMS laptop for command and control and a Remote Triaxial Sensor to measure the vibratory environment.
- ◆ SAMS current on board mass is 10.44 kg, with a volume of 0.013 cubic meters.

SAMS acceleration data



SAMS Interim Control Unit



ISS Resource Requirements

Accommodation (carrier)	EXPRESS rack 4
Upmass (kg) (w/o packing factor)	0.72 (hard drives only)
Volume (m³) (w/o packing factor)	0.0011 (hard drives only)
Power (kw) (peak)	0.04 (SAMS system power)
Crew Time (hrs) (installation/operations)	1.0 (hard drive change out, and check out)
Launch/Increment	ULF1.1/Inc 13 (hard drives up)

Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	N/A	N/A	12/1995	9/1997	1/2000	9/2000	12/2000	6A Apr 2001	Inc. 1 ⇒	TBD	TBD



Microgravity Acceleration Measurement System (MAMS)

WBS: 825080.04.02.30.01



PM: R. Hawersaat, GRC

Engineering Team: ZIN Technologies, Inc.

Glenn Research Center

Objective:

- ◆ Provide acceleration measurement system that measures the Quasi steady and vibratory acceleration data in the 0.00001 to 100 Hz frequency range on board the International Space Station (ISS) vehicle.

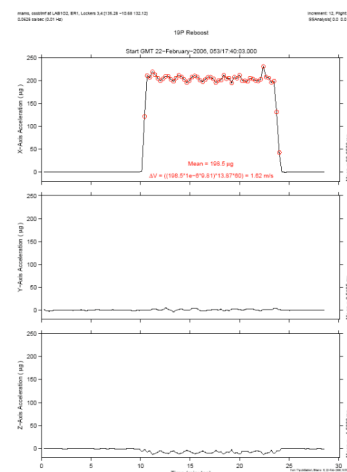
Relevance/Impact:

- ◆ MAMS will measure the acceleration environment for ISS structures as requested and provide data to vehicle dynamics for analysis.

Development Approach:

- ◆ MAMS was developed to operate with minimum crew interaction, and can be commanded with ground commands.
- ◆ MAMS supports the ISS reboosts, dockings, and exercise.
- ◆ MAMS current on board mass is 53.1 kg, with a volume of 0.154 cubic meters.

MAMS reboost data



MAMS Front Panel

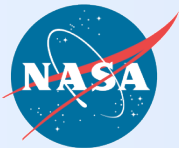


ISS Resource Requirements

Accommodation (carrier)	EXPRESS rack 1
Upmass (kg) (w/o packing factor)	0.0
Volume (m³) (w/o packing factor)	0.0
Power (kw) (peak)	0.083
Crew Time (hrs) (installation/operations)	1.0
Launch/Increment	Currently on ISS

Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	N/A	N/A	4/1997	9/1998	1/2000	7/2000	12/2000	6A Apr 2001	Inc. 1 ⇒	TBD	TBD



Binary Colloidal Alloy Test (BCAT-3 / BCAT-3+) Binodal Colloidal Alloy Test (BCAT-4)

WBS: 825080.04.02.30.04

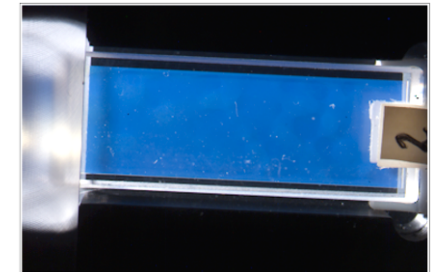


PI: Prof. David Weitz and **Co-I:** Peter Lu, Harvard University
Co-I: Prof. Paul Chaikin, Princeton University
PS: Dr. William V. Meyer, NCSER at NASA GRC
PM: Ron Sicker, NASA GRC
Engineering Team: ZIN Technologies, Inc.

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NASA Image: ISS013E08004 - Expedition 13 Science Officer Jeff Williams.



NASA Image: ISS013E26396 - Critical fluid sample 2 phase separating aboard Expedition 13.

Objective:

- ◆ Determine phase separation rates and properties of model critical fluid system. BCAT-3 results question existing theory.
- ◆ Photograph the time evolution of critical point samples onboard the International Space Station (ISS).
- ◆ BCAT-3+ will study 6 critical point samples already on the ISS.
- ◆ BCAT-4 will study 10 additional samples; 7 to add needed points to the critical point phase diagram and 3 to test properties predicted for crystallized aspherical (e.g., ellipsoid-shaped) particles.

Relevance/Impact:

- ◆ Data from the BCAT-3 critical point samples indicate that the present theory for the critical behavior of fluids is incomplete when applied to this important class of samples. When the masking effects of gravity are removed, the rate that BCAT-3 critical point samples separate into two phases show an unexpected (exponential scaling law) behavior, which seems to deviate from expected (power law scaling) behavior. The crystallization of aspherical particles in microgravity will enable tests of recent predictions and bring new understanding (e.g. CDOT showed that hard spheres do not have a glass phase).

Development Approach:

- ◆ Flight design uses existing (BCAT-3) hardware design with minor modifications.
- ◆ Using EarthKAM set-up already on the ISS minimizes upmass / volume, costs, and crew supervision, while increasing the quantity and quality of the data.

ISS Resource Requirements

Accommodation (carrier)	ISS MWA
Upmass (kg) (w/o packing factor)	0 kg (BCAT-3+ already on ISS) 2.7 kg (BCAT-4 module) + batteries
Volume (m³) (w/o packing factor)	1.76 x 10 ⁻³
Power (kw) (peak)	75 Watts (laptop and camera) + 24 / 72 AA-batteries BCAT-3+ / 4
Crew Time (hrs) (installation/operations)	8 (BCAT-3+, Inc. 15-16 remain) 26 (BCAT-4, Inc. 16,17,18)
Autonomous Ops Time (hrs)	80 (BCAT-3+, Inc. 15-16, remain) 2044 (BCAT-4, Inc. 16,17,18)
Launch/Increment	15-16 (BCAT-3+), 1 J/A (BCAT-4)

Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline (BCAT-3+)	N/A	N/A	N/A	N/A	N/A	Nov 2003	On ISS	On ISS	Incr. 13-16	Ops + 6 m	Return + 6 m
Actual/ Baseline (BCAT-4)	N/A	N/A	N/A	N/A	N/A	May 2007	July 2007	1 J/A	16,17,18	Ops + 6 m	Sept 2009



Coarsening in Solid-Liquid Mixtures-2 (CSLM-2)

WBS: 825080.04.02.30.05



PI: Peter W. Voorhees, Northwestern University

PS: Walter Duval, NASA GRC

PM: Bob Hawersaat, NASA GRC

Engineering Team: ZIN Technologies, Inc.

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Objective:

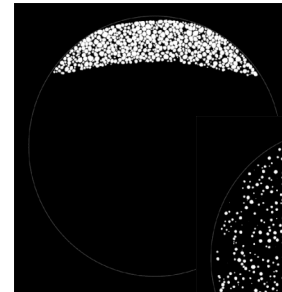
- ◆ Support the development and accuracy of theoretical models of the Ostwald Ripening (coarsening) process.
- ◆ Determine the factors controlling the morphology of solid-liquid mixtures during coarsening.
- ◆ For a two-phase eutectic mixture, determine the steady state dependence of the rate constant, particle size distribution and particle spatial distribution on the volume fraction of the coarsening phase.

Relevance/Impact:

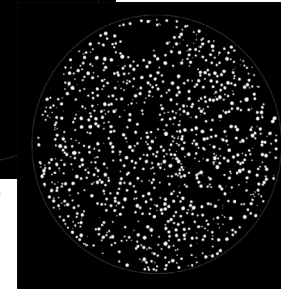
- ◆ CSLM-2 will aid in materials selection for high temperature materials, such as nuclear propulsion and waste heat coolant loops.
- ◆ CSLM-2 results will provide results that will improve design codes that are currently based on incomplete models and databases.
- ◆ Use of these improved design codes will save \$\$, Time, and Performance over conventional approaches.

Development Approach:

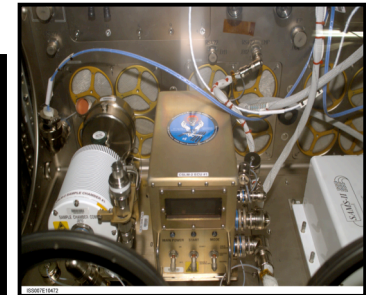
- ◆ CSLM-2 hardware design based on CSLM which flew on MSL-1.
- ◆ Electrical Control Unit (ECU) and support hardware on-orbit. Used successfully in the MSG with Sample Processing Unit (SPU) # 1.
- ◆ Samples are developed by the PI and then integrated into the SPUs by the engineering team.
- ◆ Launch 5 SPU's with high volume fractions first. If g-LIMIT is launched then launch the SPUs with the low volume fractions.
- ◆ Experiment is set up and operated by an astronaut. Some housekeeping data is down-linked.



Ground-Based Sample.



CSLM-1: Sample from MSL-1 mission.



Flight SPU#1 and Flight ECU#1 installed in the MSG on board ISS.

ISS Resource Requirements

Accommodation (carrier)	Microgravity Science Glovebox
Upmass (kg) (w/o packing factor)	33 (6.5kg/SPU) 5 SPU's up
Volume (m³) (w/o packing factor)	0.068 for 5 SPU's
Power (kw) (peak)	0.15 operate one SPU at time
Crew Time (hrs) (installation/operations)	9.7 hours crew time (2,4,10,34,48 hrs autonomous ops)
Launch/Increment	15A/Increment 17

Project Life Cycle Schedule

Milestones	ICR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual	10/1998	N/A	N/A	9/2000	9/2000	3/2002	9/2002	11/2002	8/2003	7/2005	TBD
Actual/Baseline							3/2007	6/2008	Inc. 17 /18	Inc. 18	TBD



Investigating the Structures of Paramagnetic Aggregates (InSPACE-2)

WBS: 825080.04.02.30.06



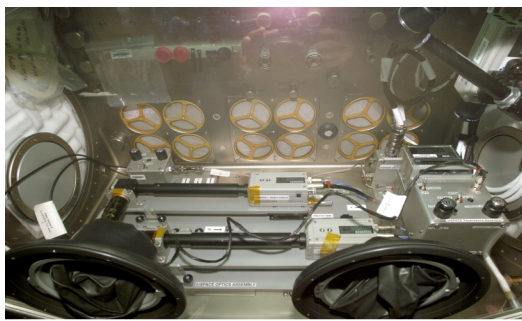
PI: Professor Dr. Alice Gast, MIT
PS: Dr. Juan Agui, NASA GRC
PM: Donna Bohman, NASA GRC
Engineering Team: EDD, NASA GRC

Glenn Research Center

Objective:

- ♦ To (1) visually study the gelation transition in magneto-rheological fluids (MR) under steady and pulsed magnetic fields, and (2) continue InSPACE-1 studies to determine the lowest energy configurations of the three dimensional structures of a magneto-rheological fluid in a pulsed magnetic field.

InSPACE in MSG



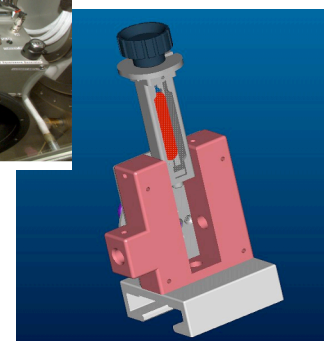
Relevance/Impact:

- ♦ MR fluids are a class of smart materials capable of changing visco-elastic properties. Microgravity data of the internal particle structure and dynamics will provide an assessment of the viscous-elastic properties. These objectives improve limb and dextrous motion in robotic components and human-robotic interfaces for EVA suits.

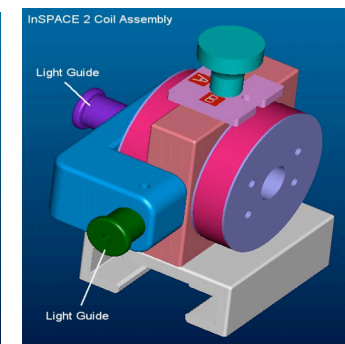
Development Approach:

- ♦ Using the hardware from InSPACE-1 already on ISS, InSPACE-2 will visually study new samples to meet the above objectives. An improved cell design will be used for imaging of the resulting aggregate structures. The new cells are dimensionally very thin in one direction reducing the optical thickness, hence providing enhanced viewing. A new coil is also provided that allows the substitution of multiple samples in two orthogonal orientations for alternate views.
- ♦ InSPACE-2 hardware consists of 1 primary Coil Assembly and 1 backup Coil Assembly, 4 vial assemblies and 4 backups.

Knob for Crew Handling



Vial Assembly



Coil Assembly

ISS Resource Requirements

Accommodation (carrier)	Microgravity Science Glovebox
Upmass (kg) (w/o packing factor)	3.57
Volume (m³) (w/o packing factor)	0.011
Power (kw) (peak)	0.030
Crew Time (hrs) (installation/operations)	14 (~2.5hr./sample)
Launch/Increment	ATV-1/Increment 15 or 10A

Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline							2006	ATV-1/10A	Inc.15/16/17		2008



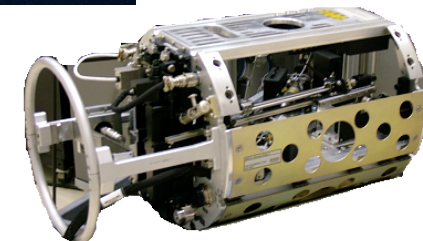
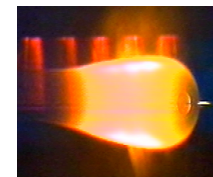
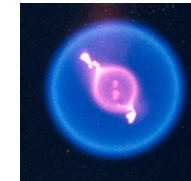
Multi-User Droplet Combustion Apparatus (MDCA)/ Flame Extinguishment Experiment (FLEX-2)

WBS: 825080.04.02.30.07



PI (Lead): Prof. Forman Williams, UCSD
PS: Daniel Dietrich, NASA GRC
PM: Terence O'Malley, NASA GRC
Engineering Team: ZIN Technologies, Inc.

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Clockwise: Image of Bi-component fuel droplet; color image of burning single fuel droplet; FLEX Chamber Insert Assembly Apparatus; image of burning droplet subjected to convective flows.

Objective:

- ♦ Modular apparatus designed for fundamental droplet combustion investigations
 - Investigate bi-component fuels
 - Examine the influence of sub-buoyant convective flows
 - Study practical fuels
 - Extend single droplet studies to binary arrays of droplets

Relevance/Impact:

- ♦ Extend single droplet combustion studies of pure fuels to consider idealized fuel mixtures and practical fuels
- ♦ Extend single droplet combustion studies to environments more relevant to engines (droplets in a flow-field and droplet-droplet interactions).
- ♦ Use experimental data to develop verified detailed and reduced-order models of droplet combustion.

Development Approach:

- ♦ PI unique fuel/gas containers built and launched to existing on-orbit Chamber Insert Assembly minimizing up-mass/volume, costs, and crew involvement

ISS Resource Requirements

Accommodation (carrier)	Combustion Integrated Rack
Upmass (kg) (w/o packing factor)	50 kg
Volume (m³) (w/o packing factor)	0.08 m ³
Power (kw) (peak)	0.73 Kw
Crew Time (hrs) - Initial configuration of CIR Rack - Change-outs during experiment	8.5 hrs 8.3 hrs
Launch/Increment	19A/TBD

Project Life Cycle Schedule

Milestones	RDR/SCR	PDR	CDR	VRR	Safety (PH-3)	PSR	Ship	Launch	Ops	Return	Final Report
Actual/ Baseline	Apr 2007	Oct 2007	Apr 2008	Sept 2008	Oct 2008	Nov 2008	L-4	Mar 2009	Apr 2009	Dec 2009	Dec 2010



Shear History Extensional Rheology Experiment (SHERE)

WBS: 825080.04.02.30.02



PI: Prof. Gareth McKinley, MIT
PS: Nancy R. Hall, NASA GRC
PM: Donna Bohman, NASA GRC
Engineering Team: ZIN Technologies, Inc.

Glenn Research Center

Objective:

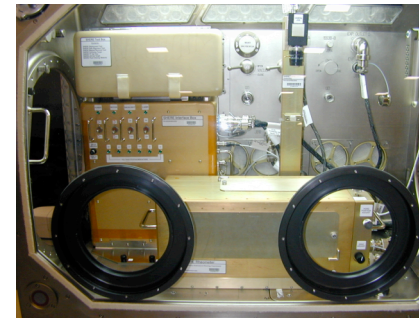
- ◆ To study the effect of preshear on the transient evolution of the microstructure and viscoelastic tensile stresses for viscoelastic polymer solutions.
 - Will investigate a controlled preshear history (from no preshear to very strong preshear) for a specified period. Then shear flow is halted and followed by exponentially increasing elongation profile axially to the polymeric liquid.

Relevance/Impact:

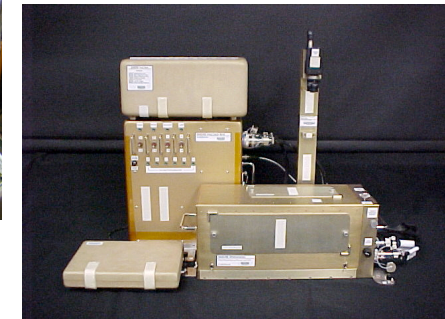
- ◆ Provide engineering design tools to optimize polymeric manufacturing processes.
- ◆ Optimization of polymer processing operations that involved *complex flows*, i.e., both *shearing* (“rotation”) and *elongation* (“stretching”).

Development Approach:

- ◆ Flight design leverages off of the Extensional Rheology Experiment (ERE) sounding rocket experiment.
- ◆ Protoflight approach used for flight hardware development.
- ◆ A high fidelity operational trainer is available.
- ◆ Experiment is set up and run by an astronaut. Some telemetry is viewed on the ground.



SHERE hardware in GBX



SHERE flight hardware

ISS Resource Requirements

Accommodation (carrier)	Microgravity Science Glovebox
Upmass (kg) (w/o packing factor)	35.4
Volume (m ³) (w/o packing factor)	0.115
Power (kw) (peak)	0.085
Crew Time (hrs) (installation/operations)	33 crew time (24 hours autonomous ops)
Launch/Increment	15A or ULF-2/Increment 17

Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	Design Rvw	VRR	Ph III FSR	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	N/A	N/A	N/A	12/2000	N/A	12/2006	4Q07	1/2008	Inc. 17	Inc. 18	TBD



Smoke Point in Coflow Experiment (SPICE)

WBS: 825080.04.02.30.03



PI: David Urban, NASA GRC
PS: Zeng-guang Yuan, NCSE
PM: Frank Vergili, NASA, GRC
Engineering Team: ZIN Technologies, Inc.

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Objective:

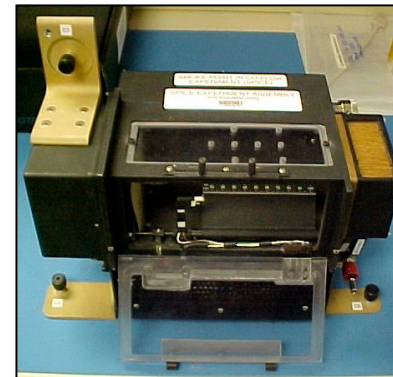
- ◆ Improved understanding of soot emission from jet flames.
- ◆ Measure smoke-point properties of jet diffusion flames in a co-flow environment as a function of nozzle diameter, co-flow velocity, fuel velocity and fuel composition.

Relevance/Impact:

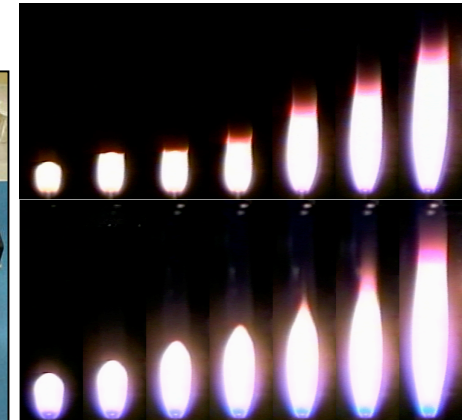
- ◆ Improved design of future space experiments using validated flame shape models and smoke height predictions.
- ◆ Support for the laminar flamelet hypothesis validation by the LSP experiment.
- ◆ Improved understanding of and ability to predict heat release, soot production and emission in microgravity fires.

Development Approach:

- ◆ Flight hardware design is based on the design of the Enclosed Laminar Flames (ELF) hardware which flew on STS-87.
- ◆ Hardware developed using a protoflight approach.
- ◆ Crew required to set up and operate the experiment. Video and data down-linked to the ground for evaluation.



SPICE Experiment Assembly



Figures show two distinct microgravity smoke point phenomena (open tip and closed tip).

ISS Resource Requirements

Accommodation (carrier)	Microgravity Science Glovebox
Upmass (kg) (w/o packing factor)	38.3
Volume (m³) (w/o packing factor)	0.096
Power (kw) (peak)	0.05
Crew Time (hrs) (installation/operations)	23.25 hours crew time (no unattended OPS time)
Launch/Increment	15A or ULF-2/Increment 17

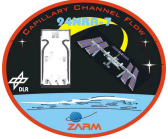
Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	CDR	VRR	Flt Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	N/A	N/A	N/A	8/99	N/A	3/08	6/08	6/08 or 8/08	Inc. 18	OPS = 4 m	Return +12m



Capillary Channel Flow (CCF)

WBS: 825080.04.02.30.08



ESA PI: Professor Dr. Michael Dreyer, ZARM

Co-I: Dr. Mark Weislogel, Portland State University

PM: Donna Bohman, NASA GRC

PS: Dr. Allen Wilkinson, NASA GRC

Glenn Research Center

Objective:

- ♦ To enable design of spacecraft tanks that can supply gas-free propellant to spacecraft thrusters, directly through capillary vanes, significantly reducing cost and weight, while improving reliability. Water will be employed to simulate the contamination process of recycling systems impact.

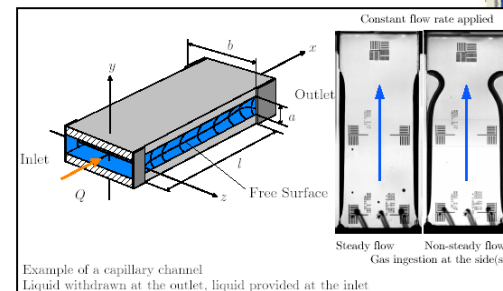
Relevance/Impact:

- ♦ The current design of spacecraft fuel tanks rely on additional reservoirs to prevent the ingestion of gas into the engines during firing. This research is required to update these current models, which do not adequately predict the maximum flow rate achievable through the capillary vanes eliminating the need to overdesign tanks.

Development Approach:

- ♦ Modularly designed system consisting of the Fluid Management System (FMS), the Board Computer (BC), and the Test Units (TU). The FMS is equipped with required components to establish the flow (pumps, plunger, valves), the TU contains the test channel, a phase separation chamber, (PSC), a compensation tube (CT), cameras for the video observation and required illumination. The experiment control, sampling of the housekeeping data, communication with the MSG interfaces and the ground station (PI site) is performed by the BC. For the investigation of the selected channel geometries (parallel channel, groove channel, wedge-shaped channel, and a liquid bridge) and different channel dimensions, the TU is exchangeable. This enables the use of the set-up for other projects with similar technology driven research objectives.

CCF in MSG



Capillary Channel Test Unit

ISS Resource Requirements

Accommodation (carrier)	Microgravity Science Glovebox
Upmass (kg) (w/o packing factor)	35-50
Volume (m³) (w/o packing factor)	0.133
Power (kw) (peak)	
Crew Time (hrs) (installation/operations)	24
Launch/Increment	TBD, Increment 18

Project Life Cycle Schedule

Milestones	SCR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline			5/2005				2008	17A/01/2009	Incr. 19	2009	2010



Zero Boil-Off Tank Experiment (ZBOT)

WBS: 825080.04.02.30.09



PI: Dr. Mohammad Kassemi, NCSSER/GRC
Co-I: Dr. David Chato, NASA GRC
PS: David Plachta, NASA GRC
PM: William Sheredy, NASA GRC
Engineering Team: ZIN Technologies, Inc.

Glenn Research Center

Objective:

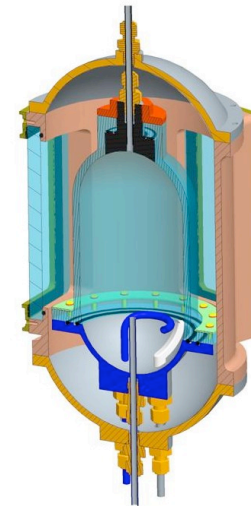
- ◆ ZBOT research will aid the design of long-term storage systems for cryogenic fluids. Simulated by HFE 7000.
- ◆ Obtain 1-g and microgravity two-phase flow data for pressure control through mixing and active cooling.
- ◆ Verify and validate a Computational Fluid Dynamics (CFD) model for cryogenic storage in 1g and microgravity.
- ◆ Use data and CFD model to assess and optimize cryogenic liquid storage design concepts.

Relevance/Impact:

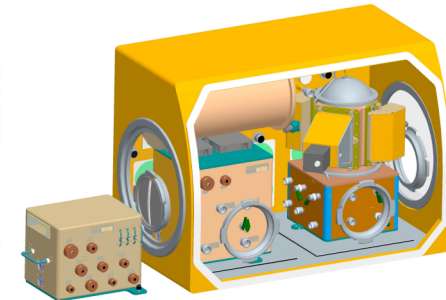
- ◆ Reduces launch mass and decreases risks through enabling design concepts for long-term storage of cryogenic fluids.
- ◆ Cost effective and reliable cryogenic storage for both life support and propulsion systems satisfying the requirements for long term mission scenarios from Moon to Mars and beyond.

Development Approach:

- ◆ Ground phase: develop ground-based experiment and obtain 1-g data for tank pressurization and pressure control.
- ◆ Flight phase: develop ISS experiment and obtain microgravity data for tank pressurization and pressure control.
- ◆ Develop a state-of-the art two-phase CFD model for tank pressurization and pressure control.
- ◆ Validate and Verify (V&V) the CFD model with microgravity and 1g data.
- ◆ Use the validated CFD model and empirical correlations derived from the 1g and microgravity data for scale-up tank design.



Test Tank Assembly



Test Tank Assembly, Fluids Box, and Reservoir in MSG

ISS Resource Requirements

Accommodation (carrier)	Microgravity Science Glovebox
Upmass (kg) (w/o packing factor)	80 - 100 kg
Volume (m ³) (w/o packing factor)	0.10 - 0.12 m ³
Power (kw) (peak)	0.100 kW
Crew Time (hrs) (installation/operations)	15 - 20 hrs
Launch/Increment	TBD

Project Life Cycle Schedule

Milestones	RCR	RDR	PDR	CDR	VRR	Safety	FHA	Launch	Ops	Return	Final Report
Actual/ Baseline	5/05	6/07	6/08	6/08	11/08	TBD	5/09	10/09	12/09	TBD	TBD



Gradient Driven Fluctuations Experiment (GRADFLEX)

WBS: 825080.04.02.30.10

PIs: Prof. David Cannell, UCSB, USA and Prof. Marzio Giglio and Alberto Vialati, U. Milan, Italy

PS: Dr. William V. Meyer, NCSER at NASA GRC

PM: Dr. Richard Rogers, NASA GRC

Engineering Team: ESA flight hardware contractors

Glenn Research Center

Objective:

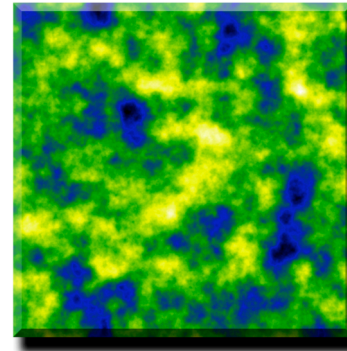
- Study gradient driven density and concentration fluctuations that are strongly enhanced in fluids by the absence of gravity.
- Achieve a quantitative understanding of gradient driven fluctuations, both on Earth and in the microgravity environment provided during a Foton-M3 mission.

Relevance/Impact:

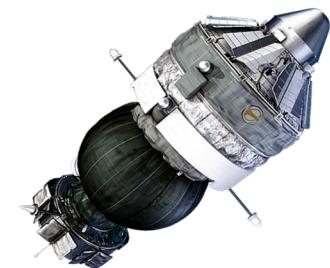
- In reduced gravity, gradients drive giant fluctuations that may impact processes such as crystal growth.
- This experiment is featured on the front-cover of the April 1, 2006 issue of *Applied Optics*.

Development Approach:

- ESA / ESTEC is funding the flight hardware and provides ground-based support in Italy.
- NASA funding allowed the development of essential prototype hardware and provides ground-based support in the United States.



Gradient driven fluctuations



Foton-M3 satellite

Resource Requirements

Accommodation (carrier)	Foton-M3 satellite
Upmass (kg) (w/o packing factor)	
Volume (m³) (w/o packing factor)	
Power (kw) (peak)	
Crew Time (hrs) (installation/operations)	None
Launch/Increment	

Project Life Cycle Schedule

Milestones	PRR	SRR	PDR	CDR	TRR	FAR	FRR	Launch	Ops	Return	Final Report
Actual/ Baseline	30 June 03	24 Mar 04	28 July 04	20 Jan 06	Sept 06	Mar 07	July 07	12 Sept 07	Sept 07	23 Sept 07	Sept 09



Boiling and Two Phase Laboratory Grant (2 ϕ Flow)

WBS: 825080.04.02.30.11

PI: Prof. Issam Mudawar, Purdue **Col:** Mohammad M. Hasan, NASA GRC

PS: John McQuillen, NASA GRC

Glenn Research Center

Objective:

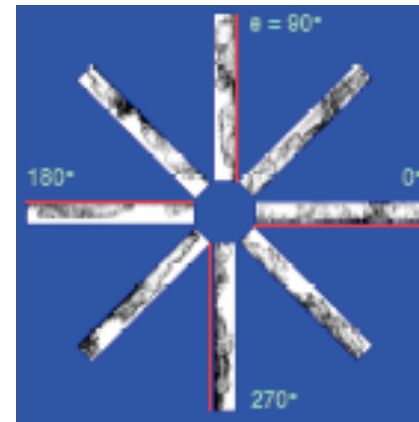
- ◆ Demonstrate the flow is Inertia Driven throughout the evaporator

Relevance/Impact:

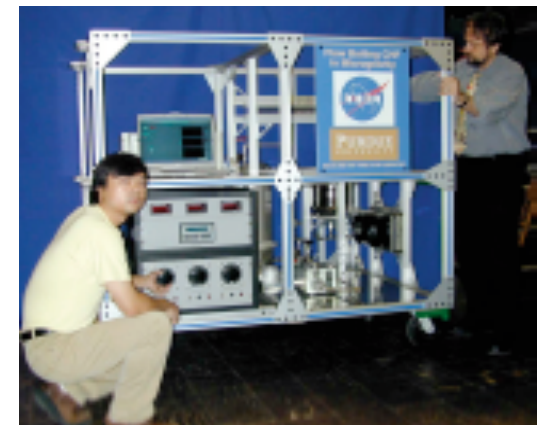
- ◆ Allow for subsystem to be tested in 1-g environment prior to space operations

Approach:

- ◆ Conduct tests under different gravity conditions using Purdue Hardware, to ascertain gravity effect on flow boiling
 - Normal gravity tests with change in alignment of gravity and flow vectors
 - Reduced gravity tests
 - Results are analyzed based on flow visualization and localized heat transfer measurements
- ◆ Model behavior



Experimental data showing effect of alignment with gravity vector on flow regimes.



Prof. Mudawar and his student next to their C-9 Reduced Gravity Experiment.

Schedule

Key Milestones/Deliverables	Date
Renew Existing Grant	Oct 2006
Grant Final Report	Sept 2007